INDOOR AIR QUALITY ASSESSMENT

Henry B. Burkland Intermediate School
41 Mayflower Avenue
Middleborough, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality
January 2005

Background/Introduction

At the request of Dr. Robert Sullivan, Assistant Superintendent, Middleborough Public Schools, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Henry B. Burkland Intermediate/Mary K. Goode Elementary School Complex (BIS/GES), 41 Mayflower Avenue, Middleborough, Massachusetts. On June 2, 2004, a visit to conduct an indoor air quality assessment was made to the BIS/GES complex by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Concerns about mold and other indoor air quality issues prompted the request.

The GES and BIS are both part of a three building complex. The BIS is in the northeastern section of the complex (Map 1). The GES is in the southwestern section of the complex. Both the BIS and GES share the central building of the complex, North and Central House. Hallways connect each of the building sections to other portions of the complex. The BIS is the subject of this report. The GES and the North/Central house building will each be the subject of separate reports.

The BIS consists of four wings, each constructed at different periods. This assessment is focused on the conditions in the northeastern wing (classrooms 1-14), which was constructed in the 1990s. The BIS building contains general classrooms, a gymnasium, cafeteria and auditorium.

The 1990 wing of the BIS was previously visited by BEHA staff on August 20, 2003 to assess mold contamination. A number of recommendations were made to remediate the mold contamination of various materials in classrooms (MDPH, 2003), which is attached as Appendix A. The BIS was also repeatedly sampled for mold by ATC Associates, an environmental consultant, in an effort to determine the efficacy of mold remediation (ATC, 2004).

Methods

BEHA staff performed visual inspection of building materials for water damage and/or microbial growth. Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The BIS houses approximately 700 students in grades 3 to 5 and a staff of approximately 50. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in six of sixteen areas surveyed, indicating a ventilation problem in some areas. A number of classrooms were sparsely occupied during the assessment due to end of the year activities. With increased occupancy, carbon dioxide levels in classrooms would be expected to be higher.

Fresh air in classrooms throughout the building is provided by unit ventilators (univents) (Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and heating coil and is then provided to the classroom by motorized fans through an air diffuser on the top of the unit. Univents were operating in all areas surveyed; however, a number of units were obstructed. To function as designed, univent diffusers and return vents must remain free of obstructions. The mechanical exhaust ventilation system consists of wall-mounted exhaust vents ducted to rooftop motors. These vents were also operating throughout the building.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix B.

Temperature measurements ranged from 72° F to 76° F, which were within the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 53 to 64 percent, which was within or slightly above of the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The wing containing classrooms 1-14 has been a source of concern due to mold colonization observed during the BEHA August 2003 assessment. The floor of the hallway leading to the classroom 1-14 wing, as well as the bottom of classroom doorframes, had visible surface mold growth only.

BEHA staff noted the following differences between the classroom 1-14 wing and the remainder of the BIS building. The classroom 1-14 wing floor is a cement slab on soil. This condition would be expected to have a lower temperature than building components not in contact with soil. The lower temperature may make the floor prone to generating condensation. Condensation is the collection of moisture on a surface that has a temperature below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. As an example, at a temperature of 80^{o} F and relative humidity of 80 percent, the dew point for water to collect on a surface is approximately 76 ^{o} F (IICR, 2000). If the floor or building components were below the dew point, condensation generation would be expected to occur. The remainder of the building is built on a crawlspace. Classrooms and hallways over crawlspaces would be less likely to have condensation since the floor is not in direct contact with soil.

Exterior wall systems should be designed to prevent moisture penetration into the building interior. An exterior wall system should consist of an exterior curtain wall (Figure 2). Behind the curtain wall is an air space that allows for water to drain downward and for the exterior cladding system to dry. At the base of the curtain wall should be weep holes that allow for water drainage. Opposite the exterior wall and across the air space is a continuous, water-resistant material adhered to the back up wall that forms the drainage plane.

The purpose of the drainage plane is to prevent moisture that crosses the air space from penetrating into the interior of the building. The plane also directs moisture downwards toward the weep holes. The drainage plane can consist of a number of water-resistant materials, such as tarpaper or, in newer buildings, plastic wraps. The drainage plane should be continuous. Where breaks exist in the drainage plane (e.g., window systems, door systems and univent fresh air intakes), additional materials (e.g., copper flashing) are installed as transitional surfaces to direct water to weep holes. If the drainage plane is discontinuous, missing flashing or lacking air space, water may accumulate inside the wall cavity and lead to moisture penetration into the building.

In order to allow for water to drain from the exterior brick wall system, a series of weep holes is customarily installed at or near the foundation slab/exterior wall system junction (Figure 2). Weep holes allow for accumulated water to drain from a wall system

(Dalzell, J.R., 1955). Failure to install weep holes in brickwork or burial of weep holes below grade will allow water to accumulate in the base of walls, resulting in seepage and possible moistening of building components (Figure 3). The exterior of the BIS consists of a traditional red brick exterior wall. An examination of the exterior brick walls of the classroom 1-14 wing was conducted to identify the location and condition of weep holes. Weep holes were found approximately at the slab level. Of note is that each weep hole was blocked with a cloth/wick material. Wicks were originally installed to enhance water movement from the drainage plane. Over time, sediment accumulation turns the wick into a stopper, which prevents water drainage from the exterior wall system. It is not recommended to "use ropes or tubes for weep[hole]s" (Nelson, P.E., 1999).

In an effort to alleviate condensation, dehumidifiers were installed in each room of the classroom 1-14 wing. Each dehumidifier was installed in a manner to drain condensation into a classroom sink, which would minimize standing water and the need to manually empty the condensation collection tank. Of note was that the dehumidifiers were operating in a number of rooms during this assessment with the classroom windows *open*. Dehumidifiers should be operated only during extended periods of hot, humid weather in the summer (the period of time that produced the mold colonization in August 2003). It is not recommended under any circumstances to operate dehumidifiers with classroom windows open, since it is can resulted in overloading of the machine, causing breakdown, overheating or possibly fire. In addition, the operation of dehumidifiers with windows open can actually enhance the draw of humid air into the building.

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. According to the NAAQS established by the USEPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a). *Carbon monoxide should not be present in a typical, indoor environment*. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detectable or ND. Carbon monoxide levels measured in the school were also ND (Table 1).

Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997).

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 43 $\mu g/m^3$. PM2.5 levels measured in the school ranged from 40 to 95 $\mu g/m^3$, which were above outdoor levels and exceeded the NAAQS in the cafeteria and some classrooms with open windows (Table 1). The front of the building has a large parking lot that had operating motor vehicles periodically during the day. In addition, some rooms had operating floor/box fans that may have reareosolized settled dust measured during this assessment. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC measurements throughout the building were also ND (Table 1).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While TVOC levels were ND, materials containing VOCs were present in the school. Located in the teacher's room are duplicating machines. One machine, the Risograph®, uses a liquid toner. Photocopiers can produce VOCs and ozone, particularly if the equipment is older and in frequent use. VOCs and ozone are respiratory irritants (Schmidt Etkin, 1992). No dedicated local exhaust ventilation for the photocopiers exists. Without exhaust ventilation, pollutants generated by duplicating equipment will accumulate in the teachers' room as these machines operate.

Of note is the use of individually purchased cleaning materials in the building. Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. The use of these products can provide exposure opportunities to a number of chemicals, which can lead to irritation of the eyes, nose or respiratory tract.

Finally, univents were examined in a number of classrooms. Univents are normally equipped with filters that strain particulates from airflow. Filters installed in BIS univents provide minimal filtration (5 % dust spot efficiency at best). In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997;

ASHRAE, 1992). Note that increased filtration can reduce airflow due to increased resistance (called pressure drop). Prior to any increase of filtration, univents should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

Conclusions/Recommendations

BEHA staff attempted to identify possible environmental sources that can be potential mold growth/allergen/respiratory irritant sources. Several potential issues influencing indoor air quality were also identified. In view of the findings at the time of the assessment, the following recommendations are made to improve general indoor air quality:

1. Remove wicks from all weep holes and clear obstructions to walls to maximize water drainage from exterior wall systems. Install appropriate media in the weep holes to prevent insect migration.
2. Remove all obstructions from univent air diffusers and return vents to facilitate airflow.
3. Operate dehumidifiers during extended periods of hot, humid weather only. Ensure windows are closed during operation. Clean/maintain dehumidifiers in a manner consistent with manufacturer's recommendations.
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate

arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).

5. Consider moving the duplicating equipment to an area that has exhaust ventilation or examine the feasibility of providing local mechanical exhaust ventilation.

6. Reduce the use of cleaning materials that contain respiratory irritants (bleach or ammonia related compounds) on floors and in classrooms. Substitute plain soap and hot water for bleach or ammonia related cleaning products. Cleaning products that contain bleach or ammonia should only be used where necessary. If bleach or ammonia containing cleaning products are used, rinse the area of application with water to remove residue.

7. Examine the feasibility of increasing HVAC filter efficiency. Ensure that filters are of a proper size and installed in a manner to eliminate particle bypass of the filter. Note that prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.

8. Consider adopting the US EPA document, “Tools for Schools” (US EPA, 2000b) as a means to maintaining a good indoor air quality environment in the building. This document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

9. For further building-wide evaluations and advice on maintaining public buildings, refer to the resource manual and other related indoor air quality documents

located on the MDPH's website at

http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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Figure 2
The Function of the Drainage Plane and Weep Holes to Drain Water from the Wall System, Prevent Moisture Penetration into the Interior

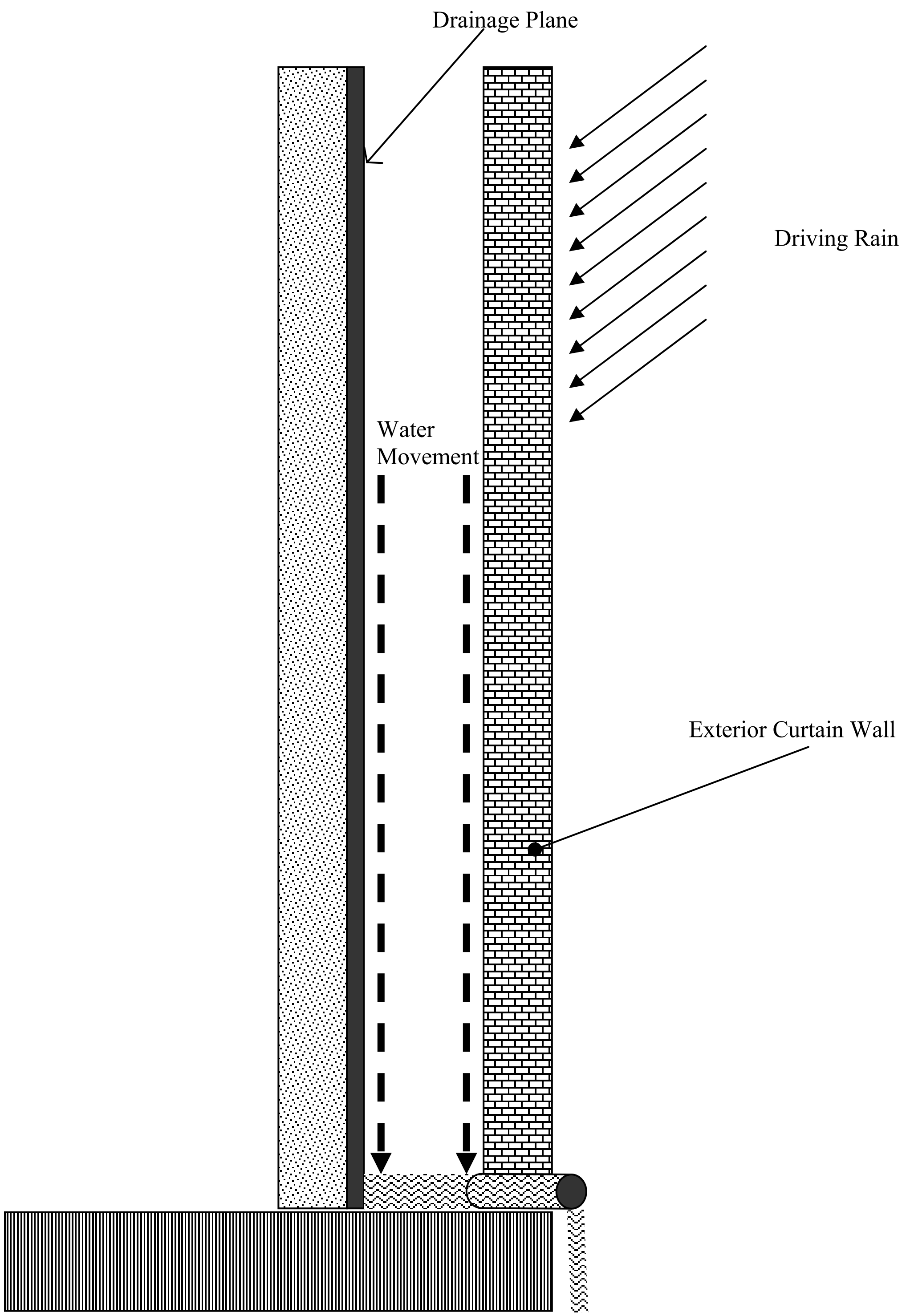
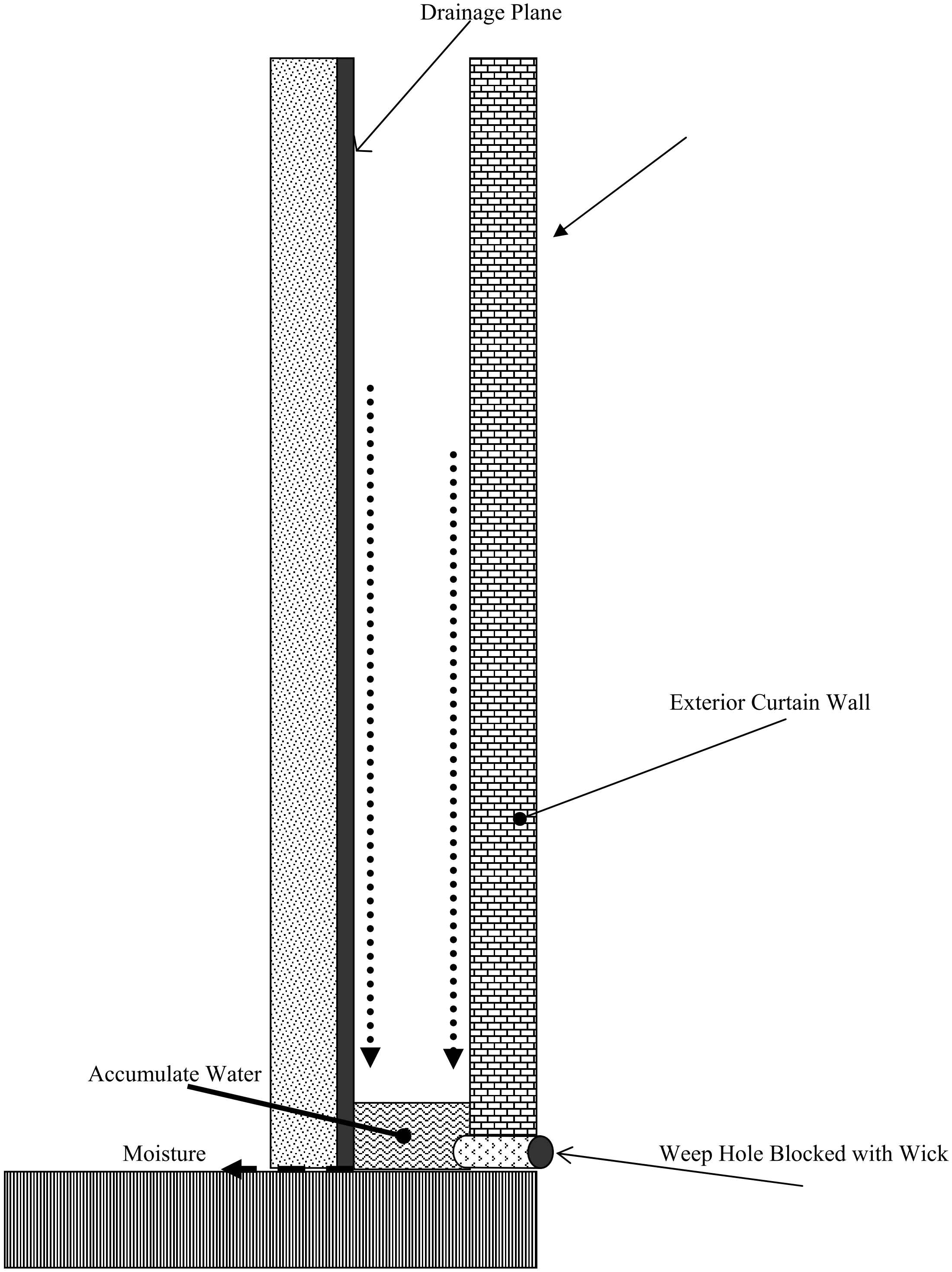
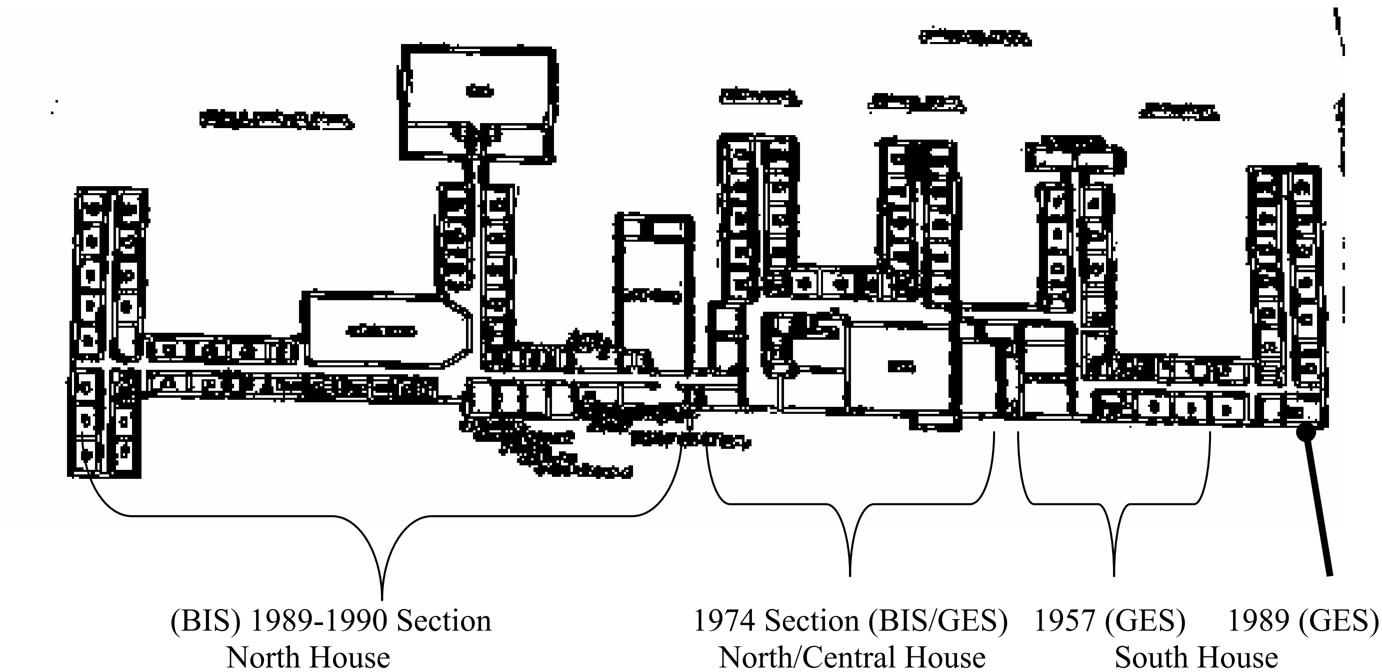


Figure 3
Weep Hole Blocked with Wick and Water Accumulation in the Drainage Plane



Map 1



Aerial View of Henry Burkland Intermediate School (BIS)/Mary Goode Elementary (GES) School Complex

Burkland Intermediate School **Indoor Air Results**

41 Mayflower Avenue, Middleborough MA **June 2, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	66	67	371	ND	ND	43			-	-	Scattered Clouds, winds: light and variable
1	74	57	437	ND	ND	42	0	Y	Y Univent	Y Wall	CD, dehumidifier-on, one window open, UV blocked
Teacher's Lounge	73	57	557	ND	ND	55	4	Y	N	N	hallway door open, PC, Risograph
Cafeteria	73	63	1111	ND	ND	80	100 +	Y	Y Ceiling	Y Wall	
EPIC/DAC	74	64	742	ND	ND	80	6	Y	N	Y Ceiling	CD, DEM, cleaners, hallway DO, 1 CT
5	74	58	619	ND	ND	83	3	Y	Y Univent	Y wall	DEM, hallway door open, plants on UV, cleaning products, personal fan
7	75	56	546	ND	ND	44	0		Y Univent	Y Wall	

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WP = wall plaster
DO = door open

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Burkland Intermediate School | **Indoor Air Results**

41 Mayflower Avenue, Middleborough MA | **June 2, 2004**

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Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
9	76	63	1221	ND	ND	95	22	Y	Y Univent	Y Wall	1 window open, dehumidifier
11	74	61	761	ND	ND	64	26	Y	Y	Y Wall	hallway door open, window open, UV blocked by furniture, dehumidifier
13	73	60	1209	ND	ND	73	22	Y	Y Univent	Y Wall	hallway door open, window open, DEM, dehumidifier, cleaning products
14	72	53	531	ND	ND	48	18	Y	Y Univent	Y Wall	DEM, chalk dust/general dust, dehumidifier
15	75	59	892	ND	ND	57	21	Y	Y Univent	Y Ceiling	DEM, personal fan, window open
17	75	59	835	ND	ND	54	20	Y	Y Univent	Y Wall	CD, cleaners, dust, 2 CT
18	74	55	586	ND	ND	41	14	Y	Y Univent	Y Wall	cleaners, UV blocked by boxes, plants, hallway door open, window open, food use/storage, clutter, dust, DEM

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41 Mayflower Avenue, Middleborough MA **June 2, 2004**

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19	74	59	752	ND	ND	40	20	Y	Y Univent	Y Ceiling	plants
20	73	55	778	ND	ND	63	16	Y	Y Univent	Y Ceiling	Hallway DO, two windows open, dehumidifier
21 B	73	59	830	ND	ND	65	19		Y Univent	Y Wall	UV blocked by boxes/furniture, dehumidifier, hallway DO

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Appendix A

The Commonwealth of Massachusetts
Executive Office of Health and Human Services
Department of Public Health
250 Washington Street, Boston, MA 02108-4619

MITT ROMNEY
GOVERNOR

KERRY HEALEY
LIEUTENANT GOVERNOR

RONALD PRESTON
SECRETARY

CHRISTINE C. FERGUSON
COMMISSIONER

September 5, 2003

Denise M Walsh, District Superintendent
Middleborough Public Schools
30 Forest Street
Middleborough, MA 02346

Dear Superintendent Walsh:

At the request of a parent and the Middleborough Board of Health, the Bureau of Environmental Health Assessment (BEHA) conducted an evaluation of the indoor air quality at the Henry B. Burkland Elementary School (BES), 41 Mayflower Avenue, Middleborough, Massachusetts on August 20, 2003. Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, conducted this evaluation. Concerns about mold as a result of excessively humid weather during the first three weeks of August 2003 prompted the request.

Relative humidity in excess of 70 percent can provide an environment for mold and fungal growth (ASHRAE, 1989). In the experience of BEHA staff, excessively humid weather can provide enough airborne water vapor to create adequate conditions for mold growth in buildings. In general, materials that are prone to mold growth can become colonized when moistened for 24-48 hours or more. Since hot, humid weather persisted in Massachusetts for more than 14 days during the month of August (The Weather Underground, 2003), materials in a large number of schools and buildings were moistened for an extended period of time. At the BES moistened materials were not dried without mechanical aids (e.g. fans, dehumidifiers, air-conditioning) and as a result, mold growth occurred.

During the course of the BEHA assessment, ceiling tiles were examined. No mold colonies were observed on ceiling tiles, however they were noticeably sagging. In previous investigations conducted by BEHA staff, sagging ceiling tiles have been an indication of an uncontrolled source of water vapor introduced into the building.

The materials listed in Table 1 were noted as either colonized with mold or in contact with mold spores. The majority of materials in the building that were colonized with mold were either non-porous building components coated with dust (e.g. floors, doorframes) or movable materials (e.g. books, computers, desks and tables) that can be cleaned or discarded. The majority of building components (e.g. walls, floors and fixtures) are non-porous surfaces constructed of materials that are not likely to be colonized by mold. Rather, these non-porous surfaces were coated with materials (e.g. dust) that can support microbial growth if exposed to moisture for extended periods of time. Therefore, cleaning of non-porous surfaces and removal of mold-colonized objects should remedy the mold contamination problem within the BES.

A decision should be made concerning the storage of certain other porous materials contaminated with mold. As discussed, boxes, documents, books and other materials can become sources of mold, spores and associated odors if moistened over extended periods of time. In this case, dehumidification and ventilation alone cannot serve to reduce or eliminate mold growth in these materials. As an initial step, options concerning the preservation of materials stored in classrooms should be considered. In some cases, surface mold on books can be removed using a vacuum equipped with a high efficiency particulate arrestance filter (Patkus, 2003; USEPA, 2001). Porous materials that are judged not worthy of preservation, restoration or transfer to another media (e.g. microfiche or computer scanning) should be discarded. When materials are to be preserved, restored or otherwise handled, an evaluation should be conducted by a professional book/records conservator. This process can be rather expensive and may be considered for conservation of irreplaceable documents that are colonized with mold. Due to the cost of records conservation, disposal or replacement of moldy materials may be the most economically feasible option.

The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended.

In order to avoid potential mold and related spore movement during remediation, the following recommendations should be implemented in order to reduce contaminant migration into adjacent areas. These recommendations illustrate the potential of mold to impact indoor air quality.

1. Use local exhaust ventilation and isolation techniques to control remediation pollutants. The design of each system must be assessed to determine how it may be impacted by remediation activities. Specific HVAC protection requirements pertain

to the return, central filtration and supply components of the ventilation system. This may entail: shutting down systems during periods of cleaning, when possible; ensuring systems are isolated from contaminated environments; sealing ventilation openings and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).

2. The following precautions should be taken to avoid the re-entrainment of these materials into the HVAC system at the BES:
   - Deactivate univents and close all windows in the area to be cleaned. Place an industrial sized fan in an open, exterior door to provide exhaust ventilation for areas to be cleaned. Be sure to place this exhaust fan in a manner to draw airborne particles away from clean areas of the building**.** This will draw air through univent filters and prevent uncontrolled draw of outdoor pollutants into clean areas of the building.
   - Seal univent air diffusers and return vents with polyethylene plastic in the areas to be cleaned. Vents for the exhaust vent system should be sealed in a similar manner.

3. Clean surfaces that do not have visible mold colonies with a vacuum cleaner equipped with a high efficiency particle arrestance (HEPA) filter.

4. Disinfect non-porous materials (e.g. door frames, linoleum, cement, Lucite topped metal desks and chairs, wood surfaces) with an appropriate antimicrobial agent is recommended. Non-porous surfaces should also be cleaned with soap and water after

disinfection. Once the second cleaning occurs, fans that introduce air from other clean areas or dehumidifiers should be used to dry cleaned area as soon as possible.

5. Porous materials that are contaminated with mold should be discarded.

6. Once cleaning of classroom is complete, seal room with polyethylene plastic and duct tape. Remove plastic from all vents in cleaned area and reactivate ventilation components (supply and exhaust). Consider creating an air lock in the hallway to reduce migration of mold contaminants to unaffected areas of the school.

7. For further advice on mold remediation consult *Mold Remediation in Schools and Commercial Buildings* published by the US Environmental Protection Agency (US EPA) (US EPA, 2001). Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html.

We suggest that the majority of these steps be taken on any remediation/renovation project within a public building. We would be happy to conduct additional tests at the school after the heating season begins to address any other IAQ issues or concerns. Please feel free to contact us at (617) 624-5757 if you are in need of further information or if you would like us to conduct further testing in the fall.

Sincerely,

Suzanne K. Condon, Assistant Commissioner
Bureau of Environmental Health Assessment

Appendix A

cc/ Mike Feeney, Director, Emergency Response/Indoor Air Quality
Robert Sullivan, Asst. to the Superintendent, Middleborough Public Schools
Fred Morris, School Principal, Henry B. Burkland Elementary
Jeanne C. Spalding, Health Agent, Middleborough Board of Health
Senator Marc R. Pacheco
Representative Thomas J. O'Brien
Representative William M. Straus
Representative Mark A. Howland

Appendix A

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Table 1

Mold Contaminated Material	Type of Material	Recommended Action
Books	Porous	• If moldy, discard • Otherwise vacuum with HEPA filter vacuum
Cafeteria tables	Non-porous	• Clean with bleach solution, then soap and water
Cardboard boxes	Porous	• If moldy, discard • Otherwise vacuum with HEPA filter vacuum
Ceiling tiles	Porous	• Spot check both sides for mold growth • If moldy, discard, otherwise clean with HEPA filter vacuum cleaner
Cloth materials	Porous	• Discard if moldy
Computers	Non-porous	• Cleaning if surface contaminated • Discard if mold entered into computer cabinet interior
Door frames	Non-porous	• Clean with bleach solution, then soap and water
Exhaust vent grilles	Non-porous	• If moldy, clean with bleach solution, then soap and water • Otherwise vacuum with HEPA filter vacuum
Lucite topped chairs	Non-porous	• If moldy, clean with bleach solution, then soap and water • Otherwise vacuum with HEPA filter vacuum
Lucite topped metal desks	Non-porous	• Clean with bleach solution, then soap and water
Particle board/binding topped tables	Porous	• Discard
Plastic storage boxes	Non-porous	• If moldy, clean with bleach solution, then soap and water • Otherwise vacuum with HEPA filter vacuum
Univent filters	Porous	• Replace prior to cleaning • Once room is cleaned, replace filters
Univent interiors	Non-porous	• Otherwise vacuum with HEPA filter vacuum
Upholstered furniture	Porous	• If moldy, discard • Otherwise vacuum with HEPA filter vacuum